The importance (impacts) of knowledge at the macro-micro levels in the Arab Gulf countries

Working Paper Series

#2013-016

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Samia Satti Osman Mohamed Nour

Maastricht Economic and social Research institute on Innovation and Technology (UNU-MERIT)
email: info@merit.unu.edu | website: http://www.merit.unu.edu

Maastricht Graduate School of Governance (MGSoG)
email: info-governance@maastrichtuniversity.nl | website: http://mgsog.merit.unu.edu

Keizer Karelplein 19, 6211 TC Maastricht, The Netherlands
Tel: (31) (43) 388 4400, Fax: (31) (43) 388 4499

UNU-MERIT Working Papers

ISSN 1871-9872

Maastricht Economic and social Research Institute on Innovation and Technology, UNU-MERIT

Maastricht Graduate School of Governance MGSoG

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Abstract

In this paper, we use the data from the firm survey (2002) at the micro level and some recent and update current secondary data at the macro level to examine the importance (impacts) of tacit and codified sources of knowledge at firm and aggregate levels respectively. Our results at the macro level are consistent with the notion that tacit knowledge is complementary with schooling, while tacit knowledge and codified knowledge are positively correlated with GDP. Moreover, at the macro/aggregate level, our results show a significant complementary relationship between codified knowledge and the number of Full Time Equivalent Researchers (FTER) and between them and publications, cooperation and technology (patents). Our findings at the micro level indicate positive correlations between tacit knowledge, ICT, training, profit, output and output diversification. In addition, our findings illustrate that tacit skill/knowledge inside the firm increases with market size: total investment, capital, firm size and age. Our results are consistent with the findings in the knowledge literature and are also useful to indicate the importance of good education at both the micro and macro levels.

Keywords: Tacit knowledge, codified knowledge, economic growth, Arab Gulf countries.
JEL classification: O10, O11, O30

[1] Corresponding Author: Dr. Samia Satti Osman Mohamed Nour, Affiliated Researcher – UNU-MERIT, School of Business and Economics, University of Maastricht, Maastricht, the Netherlands; and Associate Professor of Economics, Economics Department, Faculty of Economic and Social Studies, Khartoum University, Khartoum, Sudan. E-mail: samiasatti@yahoo.com; samia_satti@hotmail.com. The research work presented in this paper is based on a research paper prepared for the DRUID 11th Summer Conference 2006 conference on Knowledge, Innovation and Competitiveness: Dynamics of Firms, Network, Regions and Institutions, CBS, Copenhagen, Denmark, June 18-20, 2006. The author would like to thank the participants for their useful comments on this paper. All the usual disclaimers apply.

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1. Introduction

This paper examines the importance (impacts) of knowledge at the macro and micro levels in the Arab Gulf countries. Earlier findings in Nour (2005) indicate that the transfer of knowledge is successful within firms, but is somewhat doubtful between firms and universities and within society at large. Our analysis shows that within society at large, the transfer of knowledge is hindered by low skill levels, deficient educational and training systems, lack of incentives and an imbalanced structure of the population. The transfer of knowledge between universities and firms is hindered by the lack of incentives such as subsidies, and the lack of a networks, information systems, cooperation and interest in conducting joint research between universities and firms and matching the relevance of universities' research to firms needs.

One implication of our earlier analysis is that the Gulf countries need to stimulate the incidence and transfer of knowledge at the aggregate level by providing more incentives, for example through subsidies, to education and training to upgrade skill levels, and also by raising spending on R&D and ICT, organization, coordination and cooperation. Further incentives, such as subsidies, should be provided to stimulate the transfer of knowledge between universities and firms that requires a good knowledge base within firms and incentives, for example subsidies to education and training to enhance skill levels, and subsidies to R&D, networks organization, information, coordination and cooperation. In this paper we extend our earlier analysis and explain the importance (impacts) of knowledge at both micro and macro levels in the Gulf countries in more detail. In addition, we show the factors contributing to improve the tacit knowledge within firms. Due to the lack of relevant data to assess the transfer of knowledge amongst firms and between firms and universities, we focus only on the impacts of knowledge within the firms and at the aggregate/macro level. The rest of this paper is organized as follows: Section 2 briefly shows the importance and sources of knowledge in the growth literature; Section 3 presents our hypothesis to test some stylized facts about the importance of knowledge and explains the data used to test them; Section 4 discusses the main findings; and Section 5 provides the conclusions.

2. Definition, importance, sources and measurement of knowledge in the growth literature

Endogenous growth literature recognized the importance of knowledge and its accumulation as a unique source of endogenous technological progress, innovation and economic growth. For instance, in the Lucas (1988) model, knowledge accumulation is vital for the growth process, for knowledge creation, accumulation and acceleration, contribution to scientific and technological progress, innovation, economic growth performance and development. In defining 'knowledge' the literature makes a distinction between codified and tacit knowledge (Dasgupta and David (1994)). "Codified knowledge implies that knowledge is transformed into information which can either be embodied in new material goods (machines, new consumer goods) or easily transmitted through information infrastructure. While, the tacit knowledge refers to that which cannot easily transferred because it has not been stated or measured in an explicit form, skill is an important kind of tacit knowledge"[2] (cf. Freeman and Soete, 1997: pp. 404-405).

In addition, the definition of codified knowledge in the literature is closely related with investment in public spending on education, training, R&D and ICT. Several studies perceive knowledge as a public good, produced through R&D activities that generate spillover and thereby increasing returns (Romer, 1994; Grossman and Helpman, 1994). Other studies use broader terms to interpret knowledge created and embodied in institutions (cf. Langlois, 2001). For instance, Nelson (1993) and Lundvall (1992) emphasize the importance of institutions for the flows of knowledge and information to innovative capability. According to Smith: "R&D is but one component of knowledge and innovation expenditures, and by no means the largest. Because, R&D data tend to either overemphasize the discovery of new scientific or technical innovations, or to exclude a wide range of activities that involve the creation or use of new knowledge in innovation. Thus, innovation rests not only on discovery and R&D but also on learning, external environment (network) of the firm, non-R&D expenditures such as training, market research, design, trail production and tooling up and IPR costs. In addition to capital expenditure, which is a key mode of 'embodied' knowledge spillover from the capital good sector to using industries" (Smith, 2002: pp. 14-18).

Moreover, the evolutionary framework developed by Nelson and Winter (1982) makes the nature of knowledge and firms' investment in it a central factor in explaining the size, structure and dynamics of industries. Recent empirical literature (cf. Loof and Heshmati, 2002) shows that knowledge capital (defined as the ratio of innovation sales to total sales) is found to be a significant factor contributing to performance heterogeneity and a firm's innovative level. Knowledge capital rises with innovation input, the firm's internal knowledge for innovation and cooperation with domestic universities on matters of innovation. Some empirical studies indicate that survival and growth amongst firms is determined by/ or at least influenced by differential rates of investment in knowledge (such as R&D) (cf. Klepper and Simon, 1997) or intersectoral differences in the size and R&D intensity of firm (cf. Levin et al., 1985). In addition, Brusoni et al. (2002) and David and Foray (1995) show that an increasing codification of knowledge stock would increase a firm's innovative performance.

In addition, differential in the productivity and growth of different countries is significantly related to improvement in the quality of human capital, technical progress, factors of production and the capacity to create new knowledge and ideas and incorporate them in equipment and people. "Recent growth literature show increasing evidences of the growing relative importance of intangible capital in total productive wealth and the rising relative share of GDP attributable to intangible capital (Abramovitz and David, 1996; 1998). Intangible capital largely falls into two main categories: on the one hand, investment geared to the production and dissemination of knowledge (i.e. training, education, R&D, information and coordination); on the other hand, investment geared to sustaining the physical state of human capital (health expenditures). In the US, the current value of the stock of intangible capital (devoted to knowledge creation and human capital) began to outweigh that of tangible capital (physical infrastructure and equipment, inventories, natural resources) at the end of the 1960s. Moreover, since 1960s annual investment rates in R&D, public

[2] Disembodied flows of knowledge can be transmitted through movement of people, publications, etc..

education and software have grown steadily at an annual rate of 3 per cent in the OECD countries" (David and Foray, 2001: pp. 1-2).

Furthermore, Drucker (1998: p. 15) suggests: "knowledge is now becoming the one factor of production, sidelining both capital and labour". In addition, the OECD (1999:p. 7) has suggested "... the role of knowledge (as compared with natural resources, physical capital and low skill labour) has taken on greater importance".[3] Smith (2002) argues that in recent years, learning and knowledge have attracted increasing attention as a result of the claims that knowledge-intensive industries are now at the core of a growth, knowledge driven economy or even a knowledge society. The role of knowledge as an input to economic processes has fundamentally changed, probably due to rapid technological changes/ advances in ICT; ICT is seen as factor increasing knowledge and increasing the common availability of codified knowledge (David and Foray, 1995; Smith, 2002). For instance, Van Zon (2001) extends Lucas' (1988) model by incorporating the effects of ICT – capital investment and assuming that ICT has positive influence on growth performance, both by improving the intensity of production and total factor productivity and enhancing the efficiency of knowledge accumulation and learning process.

Moreover, the empirical literature shows that knowledge is positively related to human capital (mainly tacit skill or skill level). For instance, Winter (1987) suggests that tacit and codified knowledge need not be substitutes, but can be seen as complements in the learning process. Brusoni et al., (2002) show a strong positive relationship between the codification of the knowledge base of the industry and its investment in skilled people (high levels of investment in tacit skills) and R&D.

In addition, Cowan, Soete and Tchervonnaya (2001: p. 9) examine knowledge transfer in the services sector as a process by which knowledge travels from a knowledge holder (a person or organization possessing the knowledge)" to a knowledge recipient (a person or organization receiving the knowledge). In their analysis "knowledge holder is important as the "point of departure" of the knowledge being transmitted since they can influence knowledge flows".

Furthermore, the literature indicates a substantial contribution to innovation and therefore to economic growth and public welfare that can be related to an unintended spillover associated with knowledge flows.[4] Distinction has been made between three sources for the flows and transfer of knowledge: for one, Brusoni et al. (2002) highlight the importance of knowledge sources within the enterprise for innovation among innovative firms in Europe, in particular, the internal divisions (including R&D, design, sales and marketing and senior management). Several other studies have focused on knowledge flows between firms through inter-firm research collaborations (Hagedoorn et al., 2001), user-producer networks (Lundvall, 1992), or linkages between competing firms (von Hippel, 1988). Yet other studies examine knowledge flows between firms and public research organizations such as universities, public research institutes, government laboratories, and publicly-funded technical institutes (cf. Arundel et al., 2001; Mansfield, 1991; Mansfield and Lee, 1996). At the aggregate level, the transfer of knowledge is related to several variables such as the overall quantity of scientific research (publications) and the public research base as measured by the ratio between the total amount of higher education R&D expenditure and the country GDP (cf. Arundel et al., 2001: pp. 3,5).

[3] See Drucker (1998: p. 15) and See OECD (1999: p. 7) respectively.
[4] Verspagen and Schoenmakers (2000) use patent citations to measure knowledge spillover.

The notion that knowledge is a public good, produced through education, training and R&D activities that generate spillovers and increasing returns, provides a plausible justification for government intervention to compensate the private sector for the positive externalities they generate and to provide more incentives to support investment and accumulation of knowledge. While Lucas' (1988) model emphasizes investment in human capital, it only implicitly allows for a role for public policy through subsidies (Haslinger and Ziesemer, 1996: p. 230). Subsequent studies attempted to fill this gap in Lucas' (1988) model and explicitly indicate a potential role for government intervention and public policies to support the creation and accumulation of knowledge. The main channels are through taxation or subsidisation to the provision of R&D (cf. Romer, 1990; Barro and Sala-i-Martin, 1992; 1995), public knowledge: basic education and basic scientific research (cf. Ziesemer, 1990; 1995) and subsidising training (cf. Chatterji, 1995) – see earlier discussion in Nour (2005).

Korres, Patsikas and Polichronopoulos (2002) argue that knowledge can be implemented through human capital and is the key for Economic and Social development. They attempt to examine the role and the impact of "knowledge and human capital". Also, they attempt to investigate the way in which "knowledge" can be developed and disseminate and the particular effects on socio-economic effects on modernization, competitiveness and integration process.[5]

Seki (2008) argue that science, technology and innovation have become key factors contributing to economic growth in both advanced and developing economies. In the knowledge economy, information circulates at the international level through trade in goods and services, direct investment and technology flows, and the movement of people. Information and communication technologies (ICT) have been at the heart of economic changes for more than a decade. ICT sector plays an important role, notably by contributing to rapid technological progress and productivity growth. Firms use ICTs to organize transnational networks in response to international competition and the increasing need for strategic interaction. As a result, multinational firms are a primary vehicle of the ever spreading process of globalization. New technologies and their implementation in productive activities are changing the economic structure and contributing to productivity increases in OECD economies. Economic competitiveness depends on productivity level and in the knowledge economy, ICT sectors determine the productivity level. As a result , we can say that the power of economic competitiveness of a country depends on the productivity of its ICT sector. There are two ways to improve the TFP of ICT and to improve the power of competitiveness. First of all, if the selected countries solve their inefficiency problem by reallocation of resources, they can improve their TFP of the ICT sector and as a result they can be more competitive. Secondly, the technological improvement in these countries creates an expectation about increasing TFP of ICT sector for future. If there will be a sustainable technological improvement by innovation, it will cause a sustainable increase in the TFP of ICT sector and as a result it will cause a sustainable increase in competitiveness.[6]

[5] Korres, G. M., Patsikas, S. and Polichronopoulos, G. (2002) "A knowledge based economy, the socio-economic impact and the effects on regional growth," Economy Informatics, no. 1/2002 p. 5.
[6] Seki, Ý. (2008) "The Importance of ICT for the Knowledge Economy: A Total Factor Productivity Analysis for Selected OECD Countries," in Oguz Esen & Ayla Ogus (ed.), (2008) *Proceedings of the Conference on Emerging Economic Issues in a Globalizing World* Proceedings of the IUE-SUNY Cortland Conference in Economics, Izmir University of Economics, number 2008, May.

Dolfsma (2008) makes a strong and coherent contribution to the discussion of the knowledge economy and of innovation, offering a range of theoretical insights from different disciplinary perspectives. The role of knowledge, knowledge development, and knowledge diffusion is discussed at the micro level of individuals and firms, but also at the level of groups of firms and sectors, as well as at the level of the economy at large. Dolfsma (2008) analyses knowledge development and diffusion as a thoroughly social process, depending on communicative structures to support cooperation and uses empirical analyses to demonstrate where knowledge impacts the dynamics of an economy.[7]

Hollanders and Soete (2010) argues that "From 1996 to 2007, the world experienced an unbroken, historically unique period of rapid economic growth. This 'growth spurt' was driven largely by the widespread diffusion of new digital technologies and by the emergence of Brazil, China, India and South Africa on the world stage – four countries which alone represent 40 per cent of the world population. The cycle was brought to a sudden, somewhat brutal halt when the fall-out from the 'sub-prime' mortgage crisis in the USA in the third quarter of 2008 triggered a global economic recession…. National STI policies clearly face a radically new global landscape today, one in which the territorial policy focus is coming under severe pressure. On the one hand, the steep drop in the marginal cost of reproduction and diffusion of information has led to a world in which geographical borders are less and less relevant for research and innovation. Knowledge accumulation and knowledge diffusion can take place at a faster pace. This has revolutionized the internal and external organization of research and facilitated the implantation abroad of companies' R&D centres. Moreover, there is clear evidence of a concentration of knowledge production and innovation emerging *across* a wider variety of countries than before within Asia, Africa and Latin America but this knowledge is also growing at a highly differentiated pace *within* countries, wherever they may be."[8] Several recent studies in the international literature discuss several aspects related to knowledge economy and the importance of knowledge, knowledge exchange and the impact of external knowledge.[9]

3. 1. The importance (impacts) of knowledge at the micro-macro levels in the Gulf countries

In recent times, few studies discuss the status of knowledge in the Arab countries. The UNDP- AHDR (2003) examines the weak status of demand, production and dissemination of knowledge in the Arab states. Aubert and Reiffers (2003) assess the challenges and underline a strategy for the development of knowledge-based economies in the Middle East and North Africa countries (MENA). Both reports provide significant, but a somewhat general analysis at the aggregate/macro level that refers to all Arab and MENA countries respectively. Since the Gulf countries show considerable dissimilarities to the other Arab and MENA countries, at least in respect of some indicators such as structure and size of the economy, level of income and structure of labour market, it might be useful to look at them separately. Thus, one obvious advantage of our analysis is that we provide a more specific analysis that focuses only on the Gulf countries. Moreover, discernible from earlier studies, we provide a new empirical investigation of both the importance (impacts) of tacit knowledge at the micro level – see our discussion below – as well as the

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[7] See Dolfsma, W. (2008) "Knowledge Economies Organization, location and innovation," Routledge Routledge Studies in Global Competition Series – March 2008. http://www.routledge.com/books/details/9780415416658/, accessed on January 28, 2013.

[8] See Hollanders and Soete, 2010, pp. 2, 10.

[9] See Cowan and Kamath, A. (2012; 2013), see also Arvanitis, Lokshin, Mohnen, and Wörter (2013).

discrepancy in the transfer of knowledge/external schooling effects at the macro-micro levels – see earlier discussion in Nour (2005).

In this paper we use the literature presented above to examine the hypothesis concerning the importance (impacts) of tacit and codified knowledge at the macro (within society)–micro (inside the firms) levels. In particular, our aim is to test the following stylized facts:

1. At the macro level tacit knowledge and codified knowledge are positively correlated with economic growth (GDP growth), and tacit knowledge is positively correlated with schooling.

2. At the macro level codified knowledge and FTER[10] are positively correlated with each other and also with technology (patents), publications and cooperation.

3. At the micro (firm) level tacit knowledge is positively correlated with technology (ICT), upskilling (training), profit, productivity, output and output diversification.

4. At the micro (firm) level tacit knowledge is positively correlated with market size (firm size; capital; and investment) and firm age.

3. 2 . Definition of data and variables

We use the broad definition of knowledge found in the new growth literature that highlights both the tacit and codified components of knowledge. In particular, we define tacit knowledge by the percentage share of high skilled workers in total employment at the micro level[11] and the share of high skilled defined by the share of enrolment in tertiary education and the share of high (tertiary) educational attainment levels (per cent of the population aged 25 and above) at the macro level. In addition, we use the number of full time equivalent researchers (FTER) as another indicator of tacit knowledge at the macro level.[12] We define codified knowledge by the embodied knowledge distributed in many indicators, including the share of spending on R&D, education and ICT as percentage of GDP at the macro level.[13] In addition, we use several variables related to knowledge such as patents, publications, cooperation – measured by joint publications, and schooling years – defined by mean years of schooling and expected years of schooling – across the Gulf countries. Table 1 below presents the data and variables, which we use in our analysis of the importance (impacts) of knowledge at the macro/aggregate level in the Gulf countries.

[10] The concept of full–time equivalent researcher is adopted by UNESCO statistics on R&D personnel.

[11] As in Nour (2005), our definition of high skilled workers refers to workers with post secondary educational attainment: university degree and above (16 years of schooling).

[12] The main limitations of our data at the macro/aggregate level are the definition of tacit knowledge by the share/ ratios of enrolment in tertiary education (despite their drawback), the adjustment of the variables for different years and the use of unified ratio of ICT spending, due to scarcity of data.

[13] At the micro level, the definition of codified knowledge by the relative term or the share of these indicators to total output or sales value does not provide relevant results.

Table 1 - The Determinants of Knowledge in the Gulf societies (1990-2011)

	GNI PPP (current international $)		GDP		Schooling		Tacit knowledge		
	GNI per capita	GNI(current)	GDP (current US$)	GDP growth (annual %)	Mean years of schooling	Expected years of schooling	High skilled (share of enrolment in tertiary education) (%)	Share of high (tertiary) educational attainment levels (% of the population aged 25 and above)	FTER
	2011[a]	2011[a]	2011[a]	2008[a]	2011[b]	2011[b]	2001–2010[b]	2000–2007[c]	1996 c
UAE	48220	380513000000	360245000000	3.3	9.3	13.3	30.4		107
Kuwait	53820	147287000000	176590000000	4.4	6.1	12.3	18.9	8.3	440
Bahrain	21240	26801669108	22945456867	6.3	9.4	13.4	51.2	11.2	86
Oman	25770	71695822351	71781535039	12.8	5.5	11.8	26.4		82
Qatar	87030	162745000000	172982000000	25.5	7.3	12	10.2	20.9	34
Saudi Arabia	24870	698484000000	576824000000	4.2	7.8	13.7	32.8	14.9	846

	Codified knowledge				Other indicators		
	Share of public Spending as % of GDP			Total Codified knowledge			
	R&D	education	ICT		Publications	Cooperation	Patents
	2000–2007[e]	2006–2009[b]	2001[f]		2008[e]	2008[e]	(1991-1999)[g]
UAE	0.02	2.8	3.6	6.42	660	434	15
Kuwait	1.2	3.3	3.6	8.1	591	248	27
Bahrain	0.06	4.5	3.6	8.16	100	56	2
Oman	0.07	3	3.6	6.67	315	184	3
Qatar	0.06	2.5	3.6	6.16	184	152	0
Saudi Arabia	0.5	5	3.6	9.1	1745	720	103

Sources: (a) the World Bank (2012) World Development Indicators Database (2012) (b) UNDP Human Development Report (2011) (c) UNDP Human Development Report (2009) - pp. 199-200 (d) ESCWA/UNESCO (1998), (e) UNESCO estimates August (2010) and UNESCO (2012), (f) WITSA (2002), (g). US Patent and Trademark Office web site: www.uspto.gov.

As in Nour (2005), we obtain our micro/firm data from the firm survey (2002) and use three sets of indicators, including tacit knowledge (technical and non technical skills), technology and input-output variables. We define tacit knowledge by the share of high skilled/educated workers in total employment, and technology by expenditures on ICT; inputs indicators are labour (employment size) and capital (net worth), output (total sales value), output diversification (sales diversification), productivity and profit.[14]

4. The empirical results

We use the data presented above and the linear and log linear OLS regression techniques to test and compare the importance (impacts) of tacit and codified knowledge at the micro and macro levels respectively and compare the relevance of our findings to those in the knowledge literature. Based on Table 1 above, Tables 2 - 3 below present a panel data analysis reflecting the average across the Gulf countries over the period 1990-2011. Based on data from the firm survey (2002), Tables 4 -6 reflect the results across firms. Tables 2 –5 present our results, which indicate the importance (impacts) of tacit and codified sources of knowledge at the macro (aggregate) and micro (firm) levels respectively. Some of these results are consistent with the findings in the literature (cf. Abramovitz and David, 1996, 1998; David and Foray, 2001; Loof and Heshmati, 2002). Our results in Tables 2 and 3 illustrate the importance of knowledge at the aggregate/macro level. Table 2 shows that tacit knowledge – defined by the number of FTER – and codified knowledge show significant positive correlations with publications, cooperation and technology (patents). The correlations between tacit knowledge and these variables appear more significant than those

[14] As in Nour (2005), we use the same definitions of educational qualifications, ICT, diversification, output, capital, labour (firm's size) and firm's age (total years in operation)– see the definitions in Nour (2005). In addition, we obtained information on investment variables from GOIC databases.

with codified knowledge. When defining the number of FTER as one form of tacit knowledge, we find a significant positive correlation between the number of FTER and codified knowledge, which can be interpreted as complementary relationship between tacit and codified knowledge (cf. Winter, 1987; Brusoni et al., 2002). Moreover, Table 3 indicates a positive significant correlation between tacit knowledge – the share of high skilled defined by the share of enrolment in tertiary education and the share of high (tertiary) educational attainment levels (per cent of the population aged 25 and above) – and schooling years, while tacit knowledge and codified knowledge show positive correlation with GDP growth.[15] In addition, we observe from Table 1 above that the share of public spending on R&D is associated with an increase in the number of FTER, publications, cooperation and technology (patents), while cooperation is associated with an increase in both publications and technology (patents). Therefore, these results verify the first and second stylized facts that at the macro/aggregate level knowledge is positively correlated with GDP (economic growth), schooling years and technology (patents) across the Gulf countries.

Table 2– The impacts of FTER and codified knowledge on publications, cooperation and patent across the Gulf countries (1990-2011)

Independent Variable	***Constant***	***Tacit knowledge (2) (Number of FTER)***	***Codified knowledge (share of education, R&D and ICT in GDP)***	***R2***
Dependent Variable	***Coef (t-value)***	***Coef (t-value)***	***Coef (t-value)***	***R2***
Number of FTER -	*-1383.714 (-2.372)*		*221.862** (2.857)*	*0.819*
Codified knowledge	*6.631 (15.856)*	*0.003** (2.857)*		*0.819*
Number of publications	*136.097 (0.957)*	*1.742** (4.840)*		*0.924*
	-1770.978 (-1.183)		*24.835* (1.599)*	*0.625*
Cooperation	*136.581 (1.559)*	*0.611** (2.754)*		*0.809*
	-617.443 (-1.103)		*132.379* (1.744)*	*0.709*
Technology (Patents)	*-6.755 (-1.074)*	*0.119** (7.502)*		*0.966*
	-159.652 (-1.893)		*24.835** (2.212)*	*0.742*

Correlation is significant ** at the 0.01 level (one-tailed), * at the 0.05 level (one-tailed)
Notes: N = 6

Table 3 – The impacts of tacit and codified knowledge on schooling and GDP across the Gulf countries (1990-2011)

Independent Variable	***Constant***	**Tacit knowledge**		***Codified knowledge (share of education, R&D and ICT in GDP)***	***R2***
		Share of High skilled (share of enrolment in tertiary education) (%)	**Share of high (tertiary) educational attainment levels (% of the population aged 25 and above)**		
Dependent Variable	***Coefficient (t-value)***	***Coefficient (t-value)***	***Coefficient (t-value)***	***Coefficient (t-value)***	***R2***
Mean years of Schooling	*5.543 (3.939)*	*0.071* (1.576)*			*0.619*
Expected years of schooling	*11.583 (18.088)*	*0.041* (1.998)*			*0.707*
	9.684 (4.692)			0.412* (1.501)	*0.600*
Growth of GDP	*1.062 (0.591)*			*0.369[16]10 (1.632)*	*0.853*
	-12.375 (-1.226)		*1.626** (2.352)*		*0,857*

Correlation is significant ** at the 0.01 level (one-tailed), * *at the 0.05 level (one-tailed)*

[15] In contrast to our expectations, the findings at the macro level indicate insignificant correlations between codified knowledge and schooling, and between tacit knowledge – defined by tertiary enrolment ratios – and both GDP and codified knowledge.

[16] When excluding some of the observations for few Gulf countries, the coefficient in the regression equation turns significant. This result is plausible since some of the Gulf countries show a low share of public spending on education and R&D relative to GDP, when compared to other Gulf countries. This result can then be used to argue that an increase in public spending on these components would imply an increase in GDP.

Table 4 - The significance of tacit knowledge across firms, 2001

Dependent Variable	***Constant***	***Tacit knowledge (share of high skilled in total employment)***	***R2***	***N***
Independent Variable	***Coef (t-value)***	***Coef (t-value)***	***R2***	***N***
ICT expenditures	*-0.055 (-4.219)*	*0.210** (5.965)*	*0.703*	*17*
Training expenditures	*-0.036 (-2.276)*	*0.168** (4.089)*	*0.563*	*15*
Total profit	*-0.041 (-2.590)*	*0.278** (5.858)*	*0.710*	*16*
Total output (total sales value)	*0.071 (0.371)*	*0.141** (2.038)*	*0206*	*18*
Productivity (total sales value per workers)	*0.0529 (0.768)*	*0.637** (2.985)*	*0.358*	*18*
Output diversification (sales diversification)	*1.178 (8.029)*	*0.634* (1.901)*	*0.194*	*17*

*Correlation is significant * at the 0.05 level (one-tailed) ** at the 0.01 level (one-tailed)*

Table 4 verifies the third stylized fact that at the micro/firms level tacit knowledge shows positive significant correlations with technology (total expenditures on ICT) and skill upgrading (total expenditures on training), total output (defined by total sales value), output diversification (defined by sales diversification), productivity and profit.[17] From the perspective of the new growth literature, the positive correlation between tacit knowledge and output is important to prevent the diminishing returns to scale and to ensure the increasing returns and dynamic growth in the production function. This would imply that with the assumption of a potential role for public policies, the government could prevent the diminishing returns to scale and ensure increasing returns to scale, mainly through improving tacit knowledge by stimulating investment in education (basic, secondary and tertiary).

Our results from the firm survey (2002) in Table 5 bear out the assumption that increased use of tacit knowledge – defined by skilled workers, scientists and engineers – shows significant effects across firms. In particular, this contributes towards the improvement in firm production, the level of competitiveness in the local market, faster adaptation of foreign technology, utilization of technology and product quality. Moreover, Table 5 indicates that the increased use of scientists and engineers would imply additions to existing knowledge within the firm, as well as the shortening of development time and acquisition of new knowledge, the latter regarded as of somewhat less importance.[18]

Table 5 - The increasing use and effect of skilled workers, scientists and engineers across firms in the UAE, 2002 (measured in % as indicated by respondents)

(a) The increasing use of skilled workers and their effects	All firms	Chemical	Metal	Medium	Large
Increasing use of skilled workers (1999-2001)	44%	33%	60%	29%	58%
(a) The effects of increasing use of skilled workers					
1. Increase in firm production	90%	78%	100%	75%	100%
2. Effective utilization of technologies	75%	89%	64%	75%	75%
3. Improve product quality	60%	67%	55%	63%	58%
4. Improve the level of competitiveness in the local market	90%	78%	100%	88%	92%
5. Faster adaptation of technologies	80%	78%	82%	88%	75%
6. Improve the level of competitiveness in the international market	50%	78%	27%	50%	50%
Total response	20	9	11	8	12
(b) The effects of scientists and engineers on firm production and acquisition of knowledge:					
The effects of scientist and engineers	All firms	Chemical	Metal	Medium	Large

[17] There are also positive correlations between tacit knowledge and output, output diversification, productivity and profit that exceed the combined correlations of traditional inputs such as labour and capital not reported in Table 4, these results are consistent with the findings in the literature (cf. Drucker, 1998; OECD, 1999).
[18] Knowledge includes technical, scientific or marketing knowledge.

1. Add technical, scientific or marketing knowledge to areas where firms already had expertise	80%	90%	67%	76%	83%
2. Shorten development time	57%	60%	53%	53%	61%
3. Add new technical, scientific or marketing knowledge to areas where firms lacked expertise	51%	60%	40%	41%	61%
Total response	35	20	15	17	18

Source: Author's calculation based on the firm survey (2002).

Our findings in Table 6 prove the fourth stylized fact that at the micro/firm level tacit knowledge is significantly and positively correlated with market size: total investment, capital and firm size. Therefore at the micro/firm level an increase in total investment, capital and firm size would coincide with more tacit knowledge.

Table 6 - The determinants/factors enhancing tacit knowledge across firms, 2001

Dependent Variable	***Constant***	***Tacit knowledge (share of high skilled in total employment)***	***R2***	***N***
Independent Variable	***Coef (t-value)***	***Coef (t-value)***	***R2***	***N***
Firm size	*-2.887 (-3.804)*	*0.273* (1.832)1*	*0.150*	*21*
Capital	*0.195 (6.689)*	*0.0016** (2.353)*	*0.257*	*18*
Investment	*-4.520 (-3.167)*	*0.195** (2.139)1*	*0.260*	*15*
Firm age	*0.262 (2.693)*	*0.004 (0.670)*	*0.018*	*26*

Correlation is significant * at the 0.05 level (one-tailed) ** at the 0.01 level (one-tailed)
1 The logarithm of the variable is taken.

5. Conclusions

In this paper we use the firm survey (2002) data at the micro level and recent and update current secondary data at the macro level to examine the hypothesis concerning the importance/impacts of tacit and codified sources of knowledge at the micro and macro levels respectively in the Gulf countries. Our results prove this hypothesis and show that at the macro level tacit knowledge is positively correlated with schooling years, while tacit knowledge and codified knowledge are positively correlated with GDP growth (economic growth). Moreover, we find that at the macro level codified knowledge and the number of FTER show positive correlations with the number of publications, cooperation and technology (patents). Furthermore, at the aggregate level, our results imply a significant positive complementary relationship between the number of FTER and codified knowledge, which we interpret as a complementary relationship between tacit knowledge and codified knowledge. At the micro (firm) level, we illustrate the importance of tacit knowledge, which shows positive significant correlations with technology (expenditures on ICT) and upskilling (expenditures on training), output, output diversification, productivity and profit. Finally, we find that at the micro (firm) level, tacit knowledge shows positive significant correlations with total investment, capital, and firm size. This can be interpreted that higher levels of total investment, capital and firm size would correspond to more tacit knowledge across firms. Our results at the micro and macro levels verify the four stylized facts presented in the introduction, which are consistent with the general findings in the knowledge literature. The major implication of our findings is that knowledge shows positive significant correlations with many variables at both the micro and macro levels. Therefore, this would imply that public policy should provide further incentives to improve tacit and codified sources of knowledge at both the macro and micro levels. Another implication is that the positive impact of tacit knowledge also underlines the importance of good education, since tacit knowledge is often embodied in educated people and thus human capital.

Moreover, from the perspective of the new growth literature, the positive correlation between tacit knowledge and output is important to prevent the diminishing returns to scale and to ensure the increasing returns and dynamic growth in the production function. This would imply that, with the assumption of a potential role for public policies, governments could prevent the diminishing returns to scale and ensure increasing returns to scale, mainly through improving tacit knowledge by stimulating investment in education (basic, secondary and tertiary). In addition, at the aggregate/macro level, the positive correlation between GDP and codified knowledge –the share of public spending on education, R&D and ICT relative to GDP – would imply a positive role for public policy to support codified knowledge by increasing spending on education, R&D and ICT. These results are consistent with the literature that substantiate the role of public policies to support the creation and accumulation of knowledge, as explained in Section 2 of this paper and Section 5 in Chapter 3 in Nour (2005).

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